Research and Development in Composting and Animal Waste Management Including Wastewater Treatment, Renewable Energy and so on in Korea

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Abstract

As a main structure of livestock farming in Korea has been shifted from small-scale diversified farming in the past to large-scale and full-time farming. Substantiality livestock farming has become the biggest issue in livestock industry these days. The total output of livestock waste in 2012 was 46.489 million ton. Among them, recycling (including treatment of composting and liquefying) rised to 88% and purification occupied 9%. The percentage of liquefaction has gradually increased since 2006, along with the practice of policy in reducing ocean disposal. However, based on field investigation of using manure as liquid fertilization in Korea, the quality of the fertilizer was not homogeneously managed. To encourage the use of liquid fertilizer, it is necessary to develop a system of Liquid Fertilizer Quality Certification (LFQC) that is appropriate for Korean circumstance. Technology for manufacturing liquid fertilizer consistent with the LFQC should be developed as well. So, this presentation introduces the six-step manufacturing procedure of liquid fertilizer, and a plan for LFQC, which can be applied to individual farms and Multi Process of Aerobic Digestion (MPAD), and a process of resource recovery by concentrating or solidifying a variety of high concentrate.

Introduction

1. Korean livestock industry and subsequent environmental problems

In order to establish environment-friendly livestock farming, Korean government and non-governmental research institutes have put a great deal of efforts on feed manufacture, management of livestock diseases, food safety management and recycling manure. Various kinds of manure treatment have been suggested. First, for cost efficiency, treatment using saw dust, operating inexpensive machine and reducing cost on management are considered. Second, in terms of environment, odor and purification treatment are required as a type of manure treatment. Third, prevention of disease occurence is also discussed related to hygiene. From the perspective of utilizing resource, recycling by composting and liquefaction, land application and treatment of swine slurry are discussed. Finally, in terms of public service, launching public resource management, professional consultant training and integrated treatment of liquefaction and purification are required as ideal alternatives for manure treatment.

This means that integrated technique and system that can solve the problems with limited agricultural land and time constraints in applying agricultural fertilizer in each region are necessary for livestock farms.

2. Problems of different manure treatment

The number of cattle and swine farm households in Korea was estimated at 186,105 in 2010. Additionally, in terms of the status in the different types of animal waste treatment, recycling and purification accounted for 88% and 9% respectively out of 46.489 million ton (total) in 2012, which showed that the most livestock waste was treated by recycling. The increase in the percentage of converting manure to liquid fertilizer since 2006 shows that of ocean disposal has been decreasing and simultaneously, the importance of manure liquefaction has been paying attention to.

Korean government has been promoting manure treatment as a public resource recovery treatment. Through a national government project, e.g., Live-

Table 1. The percentage of maturity degree of liquid fertilizer in LMPRCs and LFSCs.

facility of manufacturing liquid fertilizer	matured		semi-matured		immatured	
	number	percentage	number	percentage	number	percentage
LMPRCs[1]	18	49%	17	46%	2	5%
LFSCs[2]	37	33%	53	47%	23	20%

[1]Livestock Manure Public Resource Center
[2]Livestock Liquid Fertilizer Supply Center

stock Liquid Fertilizer Supply Center (LFSC), storage tanks for liquid fertilizer and Livestock Manure Public Resource Center(LMPRC) are being constructed now.

3. Case study on the quality of fertilizer liquefied in Korea

It examined the quality of Liquid fertilizer in 2012, especially fertilizer using swine manure collected mainly from LMPRCs and LFSCs. The results showed that concentration of the fertilizer manufactured from each center had significant discrepancy, which required a consistent manufacturing process of liquid fertilizer to be shared.

Study1. The percentage of maturity degree in LMPRCs and LFSCs

Specimens: 150 specimens of liquid fertilizer collected from LMPRCs and LFSCs

Results: 49% maturity in LMPRCs and 33% in LFSCs

Study2. Physiochemical comparison between the properties of liquid fertilizer from LMPRCs and LFSCs

In order to know the degree of uniformity of liquid fertilizer in LMPRCs and LFSCs, pH, EC, ORP, T-N, T-P, NH_4-N, NO_3-N, $SCOD_{Mn}$ and SS were surveyed. Each means showed significant deviation between each data and confirmed that the degree of uniformity was significantly low.

4. Necessity of mid and long-term plans of livestock manure and launching Liquid Fertilizer Quality Certification (LFQC)

In May 2013, Korean Ministry of Agriculture, Food and Rural Affairs announced a plan of manure management for the next 5 years. Strong administrative supports from the government for comprehensive manure management and schedule for implementation of related projects are listed below.

< Mid and long-term plan for manure management >

◦ Objectives: construction of sustainable environment-friendly livestock industry

◦ Four main projects

1. Expand manure treatment facility:
2. Establish manufacturing system for high-quality compost and liquid fertilizer:
3. Reinforcement of follow-up management:
4. System improvement, R&D expansion and etc:

The main projects include: recycling manure, high-quality process of composting and liquefaction, construction of more LMPRCs, transition to plant farming. In order to do this, following details are required; 1) manufacturing technology of composting and liquefying manure, 2) liquid fertilizer quality certification(LFQC), 3) building marketability of compost and liquid fertilizer, 4) consistency in administrative procedure and policy, 5) integrated local management, manpower development.

5. Necessity of Liquid Fertilizer Quality Certification (LFQC)

It is essential to establish a standard for quality assurance of liquid fertilizer to prevent complaints and promote its use. There is no exact standard for the products and grades in "Regulation of liquid fertilizer using livestock waste" under the fertilizer management law of Korea. In order to promote the use of liquid fertilizer, primary Main Level-Grading Factors(MLGFs) and Evaluation Standards(ESs) of Liquid Fertilizer Quality Certification (LFQC) are needed.

Liquid Fertilizer Quality Certification (LFQC), under research at present (2013), is a system where liquid fertilizer using manure is classified by four Main Level-Grading Factors (MLGFs: fertilizer efficiency,

environmental risks, stability and uniformity). The classified liquid fertilizer is scored according to the Evaluation Standards(ESs) in detail and graded into A, B and C so that the grading system can allow to develop high-quality products based on Grade A and enlarge marketability of commercial liquid fertilizer in the future.

Based on the system, it is required to develop a new strategic product in livestock environment industry by reviewing and gathering a wide variety of opinions with various experts.

6. The cases of research on liquefying technology in Korea

6.1 Introduction of six-step method for manufacturing liquid fertilizer

Most of Korean Swine farms do not fully equip with liquefaction technology so that a standardized process of liquid fertilizer is needed. Table 2 suggests a model of liquid fertilizer process necessary for Korean swine farms on the spots.

6.2 Introduction of MPAD

For fast transportation of liquid fertilizer from region to region, concentration method using membrane separation technology has been recently studied. Development of environment-friendly and future-oriented resource recovery techniques, which allows management of pathogenic microbe and manufacture of functional liquid fertilizer, is needed. MPAD (Multi Process of Aerobic Digestion)system introduced in this study is comprised of three different types of process; Thermophilic Aerobic Oxidation (TAO) system, lime solidification system, and membrane system with MF and Reverse Osmosis(R/O). Characteristics of each process are simply accounted for below.

1) TAO (Thermophilic Aerobic Oxidation) System
   The wastes in a manure tank were transferred to the biological process, the TAO (thermophilic aerobic oxidation) system by using a pump. Strong mixing and aeration were performed at the same time so self-heat (auto-thermophilic, 55°C) reaction was induced by thermophilic bacteria.
2) Lime solidification system
   Floating particles in the livestock wastes after treatment of TAO system could be solidified. It is composed of a condensed sample control part, 1st - 2nd condensation part and a filter press. In the control part, to process thermophilic aerobic fermented liquor, lime was added to increase pH up to 9~12. The solidification of the liquid was maximized after adding Iron chloride, polymer coagulant. Then, it was filtered by the filter press to make cake.
3) Membrane system with MF and Reverse Osmosis
   Reverse osmosis is a selective penetration membrane system to remove dissolved solids like metal ion. It is composed of a pre-pump and a high pressure pump for osmotic pressure leading to MBR system with MF membrane.

Table 2. Features and target standards in each step of standardized six-step liquefying process.

6 steps		remarks	
1	step of swine slurry management	-inflow BOD: 30,000 ppm -Oxidation-Reduction Potential (ORP): less than -300mV	-outflow BOD: around 20,000 ppm
2	step of solid-liquid separation	-BOD after solid-liquid separation: 10,000 ppm	
3	1st step of fermentation	-inflow BOD: 10,000 ppm -processing period : 3- 20 days -ORP: maintain -50mV -volatile fatty acid: less than 300 ppm	-outflow BOD: below 5,000 ppm
4	step of returning fermented liquid fertilizer	-return 20 to 50% of fermented liquid fertilizer to swine slurry process	
5	2nd step of fermentation	-inflow BOD: less than 5,000 ppm -processing period: 30 days -air supply: 30 - 60 L/ m^3.min -ORP: maintain below -150 ~ -50mV -nitrogen concentration: maintain 2,500 ppm	-outflow BOD: below 1,000 ppm
6	step of applying to farmland	-operate program of applying liquid fertilizer in a year	

Table 3. Bio-chemical concentration in each step of MPAD system

Item	BOD_5 (mg/L)	CODMn (mg/L)	SS (mg/L)	T-N (mg/L)	T-P (mg/L)	E. coli (CFU/㎖)
Influent	34,540	25,877	40,927	4,864	1,082	47,837
TAO Fermentation liquid fertilizer	8,286	10,036	38,117	3,846	964	N.D*
1st Lime solidification	3,729	5,019	1,042	3,113	29	N.D*
2nd Lime solidification	1,119	2,510	150	2,959	7	N.D*
MF, R/O concentration liquid fertilizer	4,121	5,268	255	5,261	16	N.D*
R/O discharged water	15	25	3	43	0	N.D*
Efficiency(%)	99.9	99.9	99.9	99.1	99.9	100

*N.D : Not Detected

Table 3. shows the changes in bio-chemical concentration during each step of MPAD through which swine manure was treated. This pilot-scale process is operated on-farm with a level of a laboratory.

Conclusion

The main purpose of the Korean policy for livestock manure management is to promote utilizing manure as a high quality resource by composting and liquefying. This enables to increase the value of livestock manure in hygienic, economic and functional ways. Main policy of recycling manure is summarized into four below.

① Develop manure management as a new key industry by using the properties of manure
② Create high added value reflecting plant farms' point of view
③ Build integrated and cooperative technology system for high-quality resource recovery of manure
④ In order to optimize manure recovery management, economic, social and technological value and improvement of system should be considered together and the related technology should be developed as "an axis of growth in sustainable livestock farming."

Additionally, focus should be put on the development of social co-operatives and cooperative associations as a new business that can possibly deal with rural slumism resulted from aging, polarization and the elderly poverty.

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